Towards a quantification of agricultural carrying capacity in the past: the application of a soil erosion model to estimate crop productivity

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Humans have impacted their environment throughout history, especially since the introduction of widespread agriculture and the associated forest logging activities, thereby creating anthropogenic landscapes in which environmental processes are no longer in equilibrium. Under certain conditions, this has led to a drastic reduction in carrying capacity with negative feedback to the sustainability of society. Soil erosion and the resulting reduced agricultural productivity has been pushed forward as one of the contributing factors responsible for the collapse of ancient societies. Yet, quantitative data supporting these hypothesis is still lacking. Furthermore, more attention was recently given to the resilience of ancient societies against soil erosion and its negative consequences, challenging the ideas of collapse. In order to tackle these questions, local site-specific information on land use and soil erosion needs to be upscaled to entire regions or territories. A modeling approach can help to achieve this. The territory around the ancient city of Sagalassos (Taurus Mountains, SW Turkey) was selected to quantify crop productivity through space and time. In order to simulate erosion, the spatially distributed soil erosion & sediment delivery model WaTEM/SEDEM was used. Results show how land cover variations and the depletion of soil reservoir have a larger influence on the central valley sedimentation rates in comparison to climatic variability. The general amount and spatial pattern of net erosion was well reproduced by the model, although it failed to capture the more detailed field work derived sedimentary chronologies. The soil erosion model offers the opportunity to get information on soil depths in both space and time, which can be used as input for the crop productivity model. The model results from the Gravgaz catchment show how deforestation and agriculture led to the depletion of the existing soil reservoir while creating agricultural potential in the central valley's through the accumulated sediments. Although preliminary results show that soil thickness on its own isn't a strong predictor for crop yields, future work will include soil thickness at least as one of the factors controlling crop productivity. Promising soil properties – crop yield relations can be found in literature, but they still need to be verified for the territory of Sagalassos. Hence, present day crop yield data need to be collected to form a basis for model validation. Furthermore, soil properties of ancient soils will have changed throughout time. Therefore, the model will have to include the dynamic properties of soils over time.